The Economics of Biodiversity in Urbanizing Ecosystems

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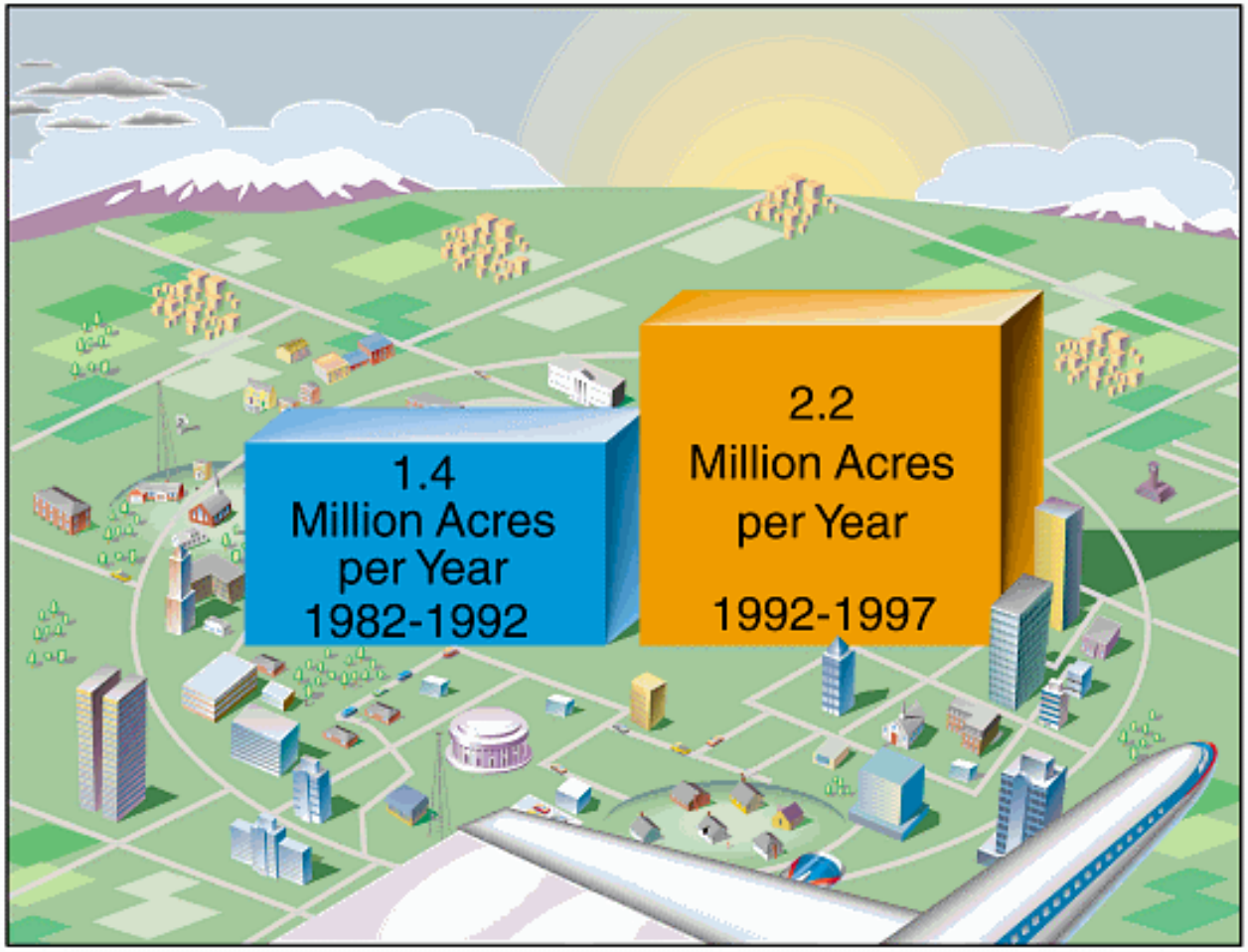
Purpose of Talk

- What are impacts of urbanization on natural systems?
- What natural system services are at risk from urbanization?
- How valuable are those services?
- Why do land markets not adequately protect those services?

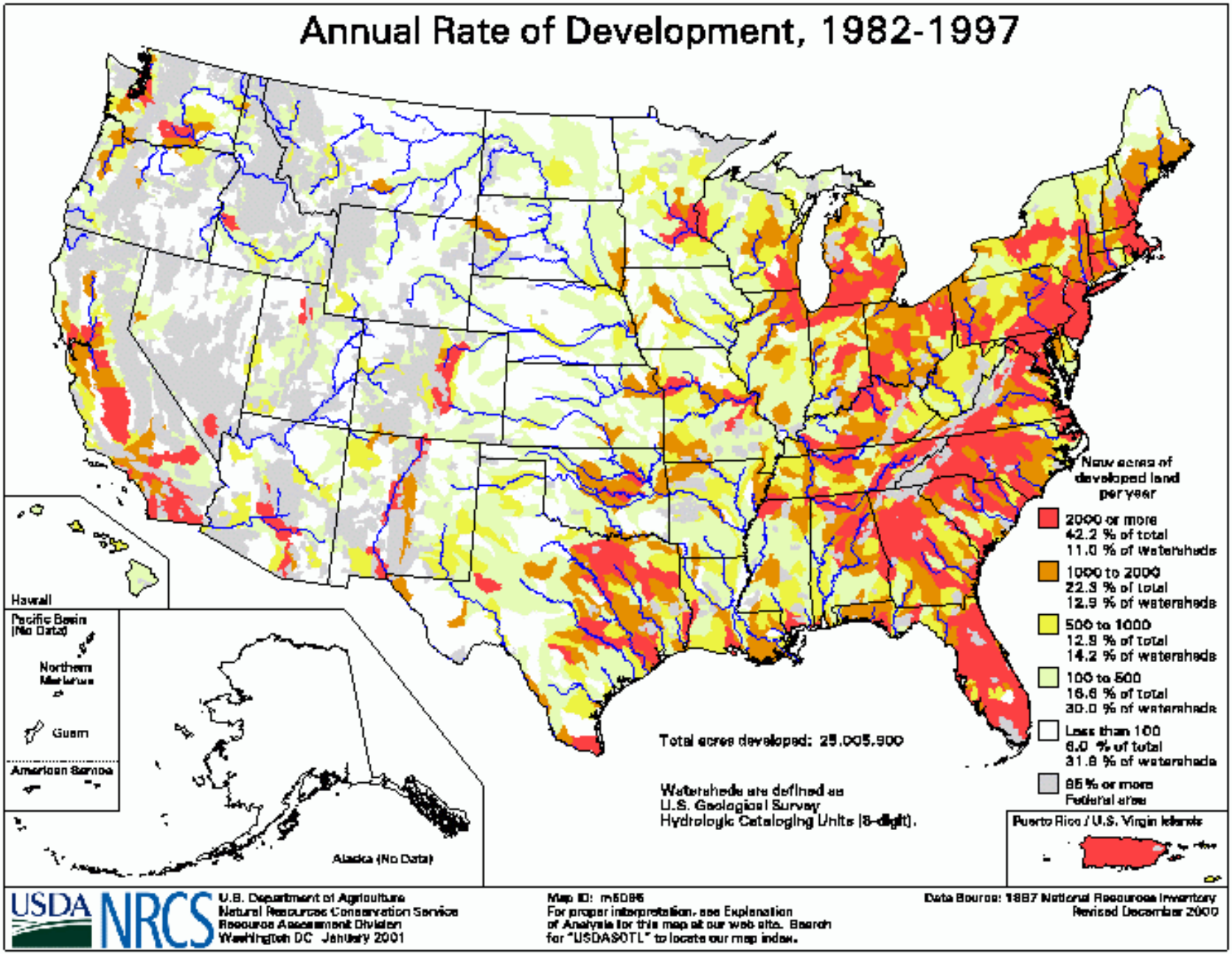
Urban Sprawl

- Between 1982 and 1997, urbanized land increased 47% while population grew by only 17% (Brookings, 2001)
- 1% of forest and 1% of cropland converted to development between 1992 and 1997 (USDA, NRI, 2000)

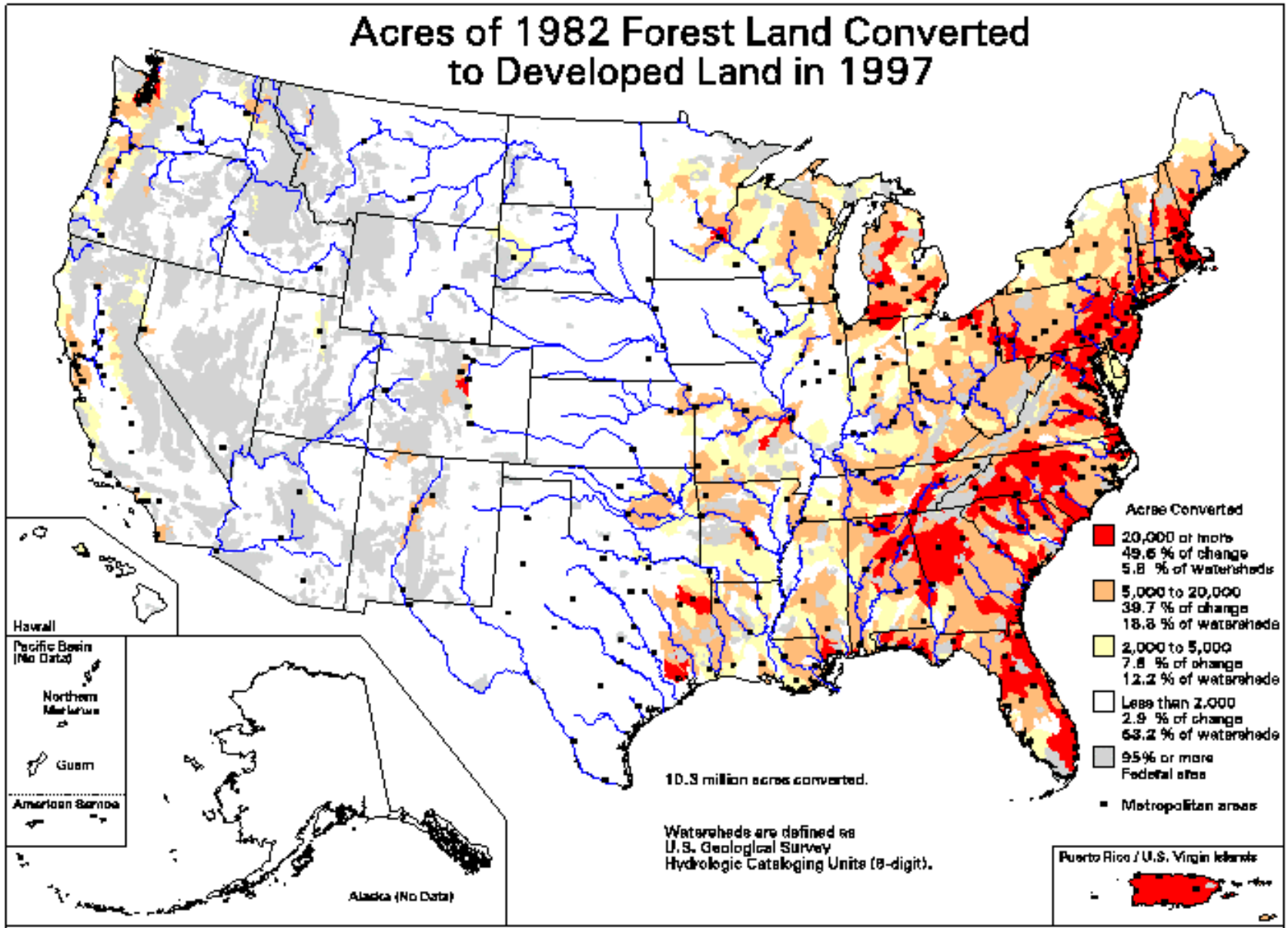
Land Converted to Development



Source: USDA, Natural Resources Conservation Service
1997 National Resources Inventory
Revised December 2000


Annual Rate of Development, 1982-1997
New acres of developed land per year
2000 or more
42.2 % of total
11.0 % of watersheds
1000 to 2000
22.3 % of total
12.9 % of watersheds
500 to 1000
12.9 % of total
14.2 % of watersheds
100 to 500
16.6 % of total
30.0 % of watersheds
Less than 100
6.0 % of total
31.8 % of watersheds
85% or more Federal area
Total acres developed: 25,005,900
Watersheds are defined as U.S. Geological Survey Hydrologic Cataloging Units (8-digit).
Hawaii
Pacific Basin (No Data)
Northern Marianas
Guam
American Samoa
Alaska (No Data)
Puerto Rico / U.S. Virgin Islands
USDA NRCS
U.S. Department of Agriculture
Natural Resources Conservation Service
Resource Assessment Division
Washington DC January 2001
Map ID: m5085
For proper interpretation, see Explanation of Analysis for this map at our web site. Search for "USDASOTL" to locate our map index.
Data Source: 1997 National Resources Inventory
Revised December 2000

Acres of 1982 Forest Land Converted to Developed Land in 1997

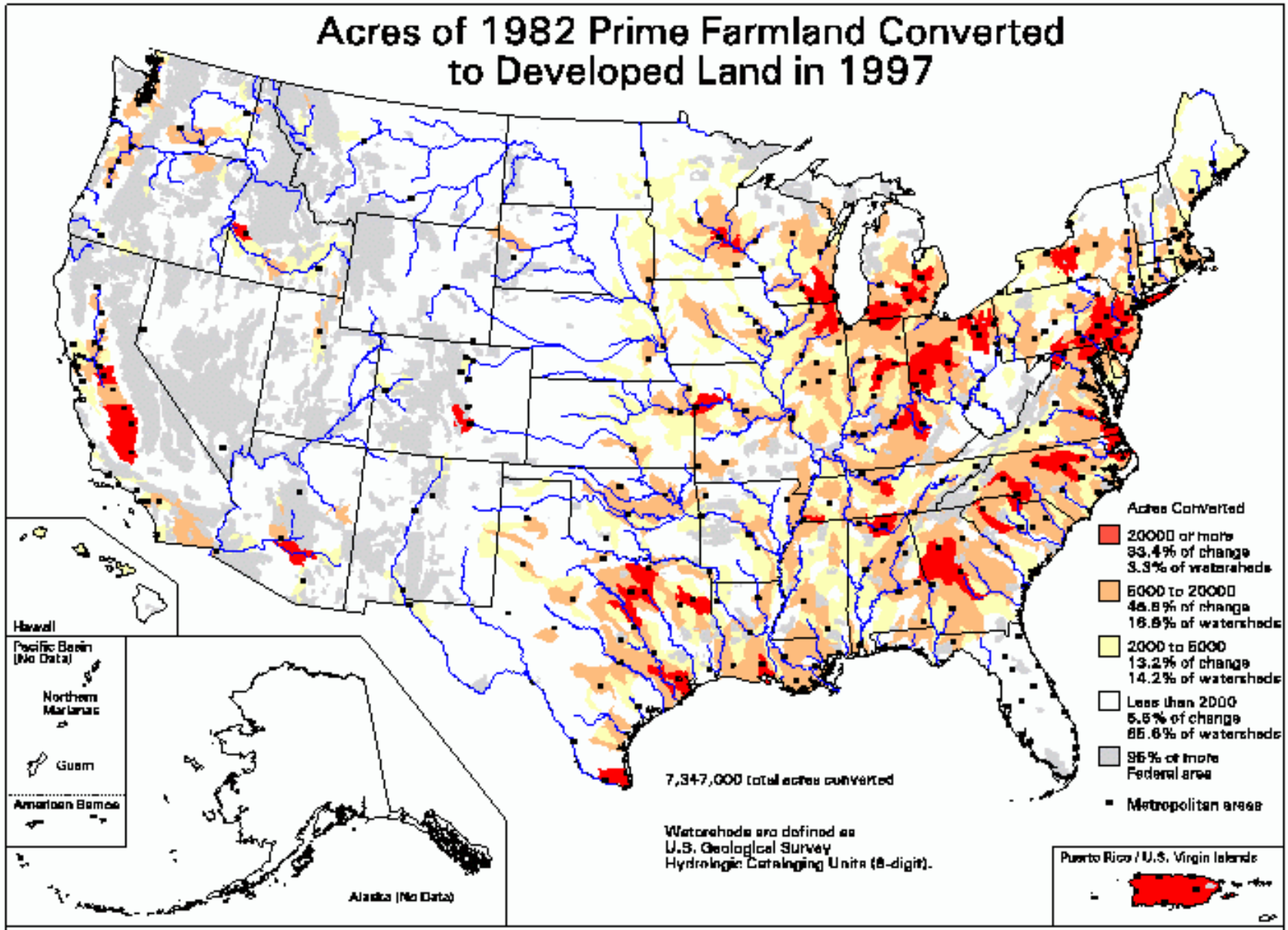


USDA NRCS
U.S. Department of Agriculture
Natural Resources Conservation Service
Resource Assessment Division
Washington DC March 2001

Map ID: rs5873
For proper interpretation, see Explanation of Analysis for this map at our web site. Search for "USDASOTL" to locate our map index.

Data Source: 1997 National Resources Inventory
Revised December 2000

Acres of 1982 Prime Farmland Converted to Developed Land in 1997



USDA NRCS
U.S. Department of Agriculture
Natural Resources Conservation Service
Resource Assessment Division
Washington DC January 2001

Map ID: m5078
For proper interpretation, see Explanation of Analysis for this map at our web site. Search for "USDABOTL" to locate our map index.

Data Source: 1997 National Resources Inventory
Revised December 2000

Urban Sprawl and Biodiversity Losses

- Urban sprawl is a worldwide phenomenon, with urbanized populations growing at four times the rate of rural populations (World Resources Institute, 1998).
- The major single cause of biodiversity loss is habitat loss and degradation (Ehrlich, 1988).
- Urban sprawl, defined as low density development of natural areas outside cities and towns, was directly responsible for imperiling 188 of the 286 California species listed as threatened or endangered under ESA (National Wildlife Federation, 2001).

- The above CA study showed that sprawl was indirectly associated with species imperilment through introductions of non-native species, outdoor recreation activity, road construction, modified fire regimes and pollution.
- A study of the Chicago metropolitan area found that natural land cover declined from 20% to 16% of total land use/cover between 1972 and 1997 (Wang and Moskovits, 2001).
- The Chicago study found that “unassociated vegetation,” which represents fragmented, degraded patches of non-native woody and grassy vegetation, increased from 7% of land use/cover to 22% over the same period.

- Bird densities were reduced significantly up to 1000 meters from roads, and the reduction was particularly severe for songbirds (Forman and Deblinger, 2000).
- Road densities were significantly related to the loss of wetlands dependent herptile and bird species richness albeit with a lag of up to a decade (Findlay and Bourdages, 2000).

Yet…..

White, et al. (1997) show that effective planning in a rapidly urbanizing landscape in Eastern Pennsylvania could diminish by half the proportion of habitats at risk from urbanization.

Major Ecological Economic Questions…

- Aren't these urban sprawl settlement patterns simply a reflection of supply and demand that serve us so well?
- So what if biodiversity losses occur. What are the associated losses to human welfare?
- Do we really need to manage growth with biodiversity in mind?

Biodiversity is a Portfolio of Natural Assets

- Like financial portfolios, it is prudent to maintain diversity.
- These natural assets yield returns, both economic and non-economic.
- Wise ecosystem management requires consideration of the diversity of species and ecosystems, and their returns.

Focus of Management is then:

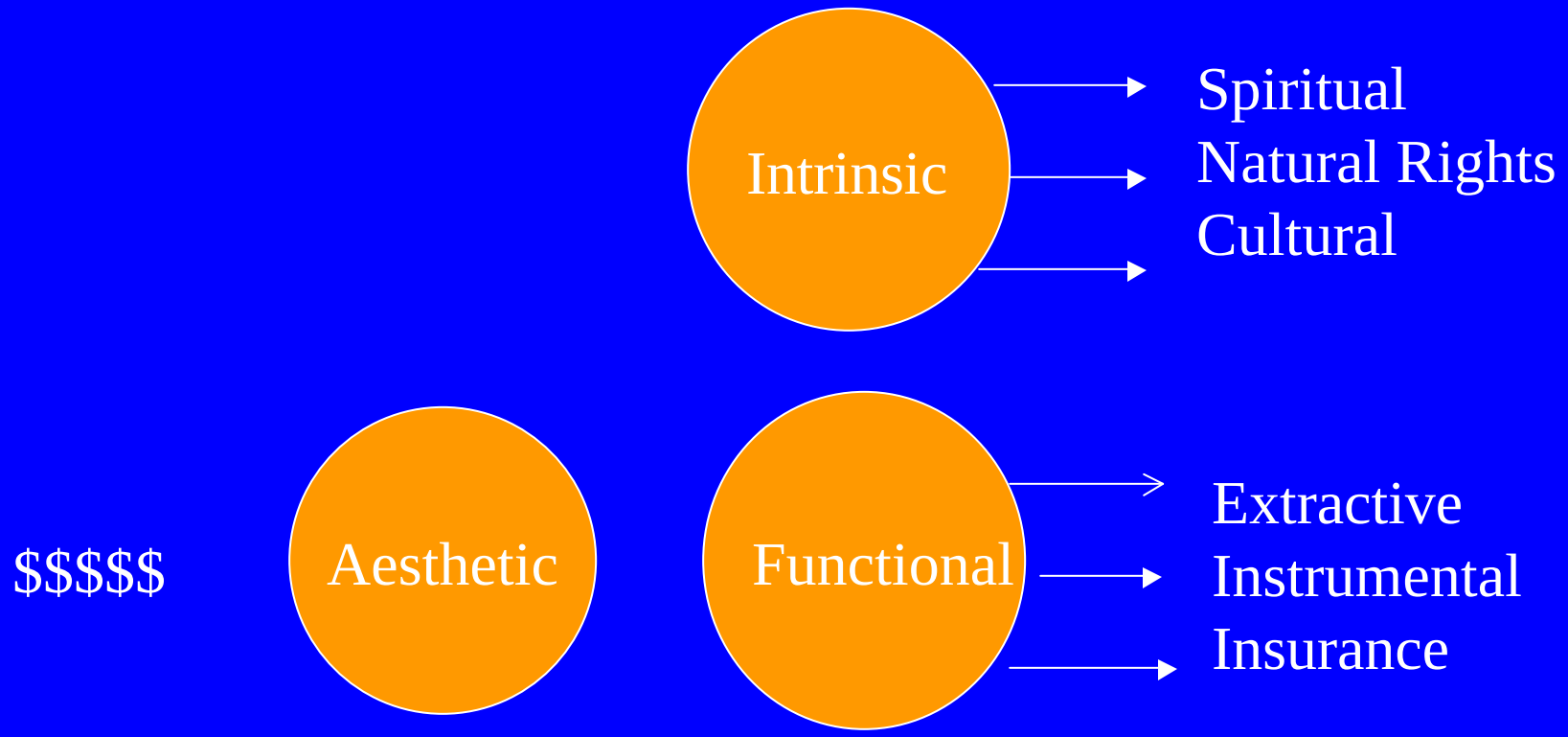
- Maintaining a viable and healthy ecosystem for the sustainable flow of its goods and services, and insurance against catastrophic change
  - Maintaining reliability of important ecological functions
  - Maintaining dynamic adaptability and resilience of ecosystem to change
- Evaluating ecological-economic connections

Recent research on natural systems has highlighted the economic values of the services of these systems to humans and their economies

(Daily, 1997; Baskin, 1997).

Figure 1

Human Values of Natural Systems



The economic valuation of biodiversity and nature's services is based upon two principles:

- Human welfare enhancement –Nature can do it better (parks, wildlife areas, streams…)
- Cost Savings – Nature can do it more cheaply (flood protection, soil management, water purification…)

Most natural services are not sold directly in markets.

When there are no explicit markets for services, we must resort to more indirect means of assessing economic values.

Economic Valuation Techniques

- Avoided Cost (AC): services allow society to avoid costs that would have been incurred in the absence of those services; flood control provided by forests avoids property damages, or waste treatment by wetlands avoids health costs.
- Replacement Cost (RC): services could be replaced with costly man-made systems; natural waste treatment of wetlands and vegetative cover can be replaced with costly treatment systems.

- Factor Income (FI): services provide for the enhancement of incomes; water quality improvements provided by streamside vegetation increase incomes of the water recreation service industry.
- Travel Cost (TC): service demand may require travel, whose costs can reflect the implied value of the service; urban recreation sites attract distant visitors whose value placed on those sites must be at least what they were willing to pay to travel to them.

- Hedonic Pricing (HP): service demand may be reflected in the prices people will pay for associated goods; housing prices are higher near parks and forested areas.
- Contingent Valuation (CV): service demand may be elicited by posing hypothetical scenarios that involve some valuation of alternatives; people would be willing to pay for the aesthetics of a forested or agricultural landscape.

Nature's Services

- Regulation of Natural Processes
  - Gas
  - Climate
  - Disturbance
  - Water cycling and quality
  - Soil formation and retention
  - Waste treatment
  - Pollination
  - Biological control

- Habitat Availability
  - Refugium
  - Nutrients
- Production
  - Food
  - Raw materials
  - Genetic resources
- Recreational
- Cultural and Spiritual

Valuation Example

- Deforestation of urban ecosystems can dramatically reduce the ability of vegetation and soils to retain water.
- Streamside vegetation loss can result in the increased flow of both natural and human nutrients into streams.

Valuation:

- Experimental clearing of a New Hampshire forest resulted in a 40% increase in average stream flow, and during a four-month period increased rainfall runoff five times greater than normal (Ecological Society of America, 2001).
  - What are downstream property damage increases under storm events?
  - What are downstream containment costs?

- Urban sprawl and stream quality
  - Increases in population density reduce tree cover.
  - Reduction in tree cover reduces attainment of Clean Water Act standards

    (see following figures)

Figure 2

Population Density and Tree Cover, Allegheny County, PA

(Argueta and Farber, 2001)

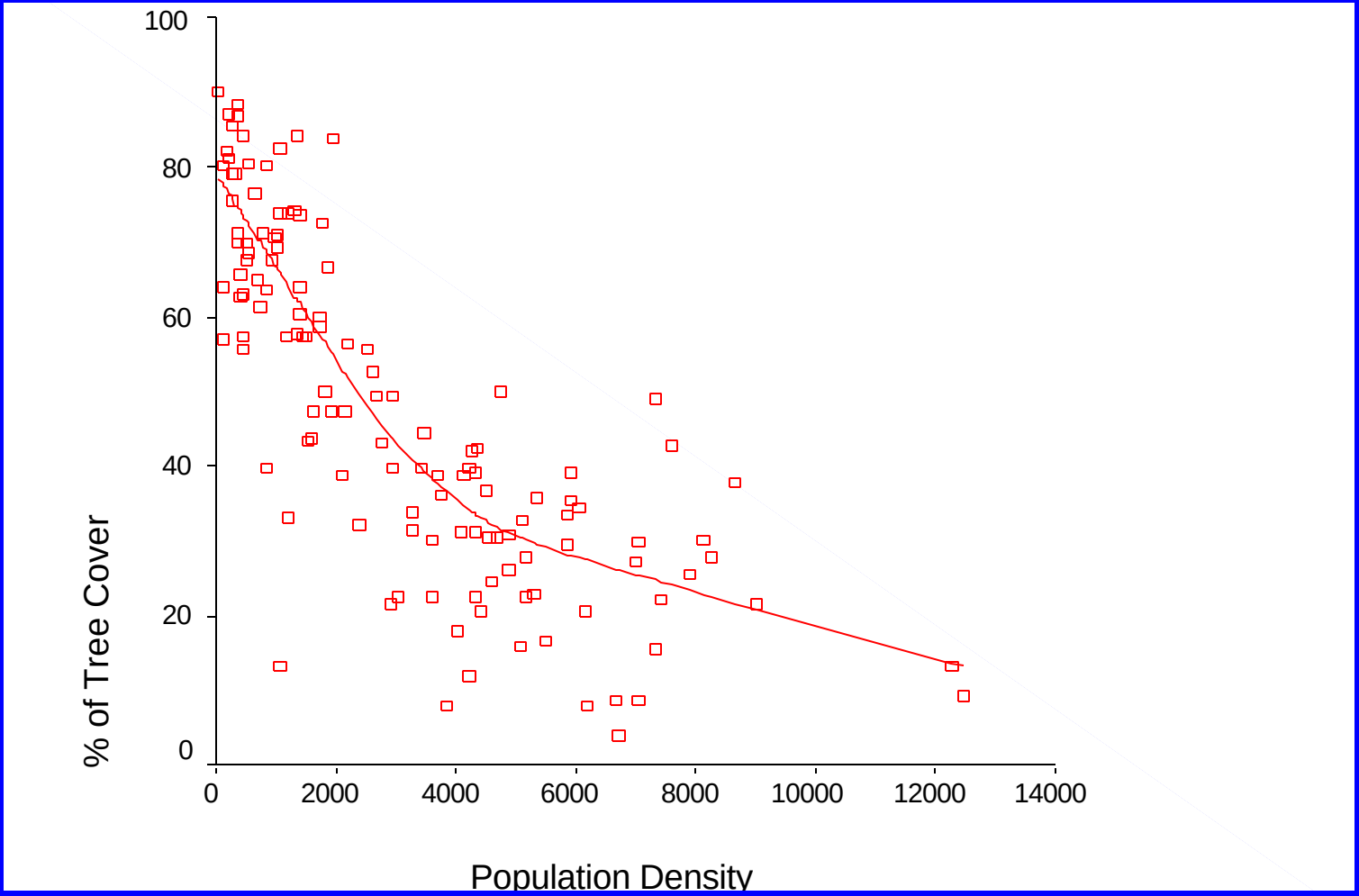
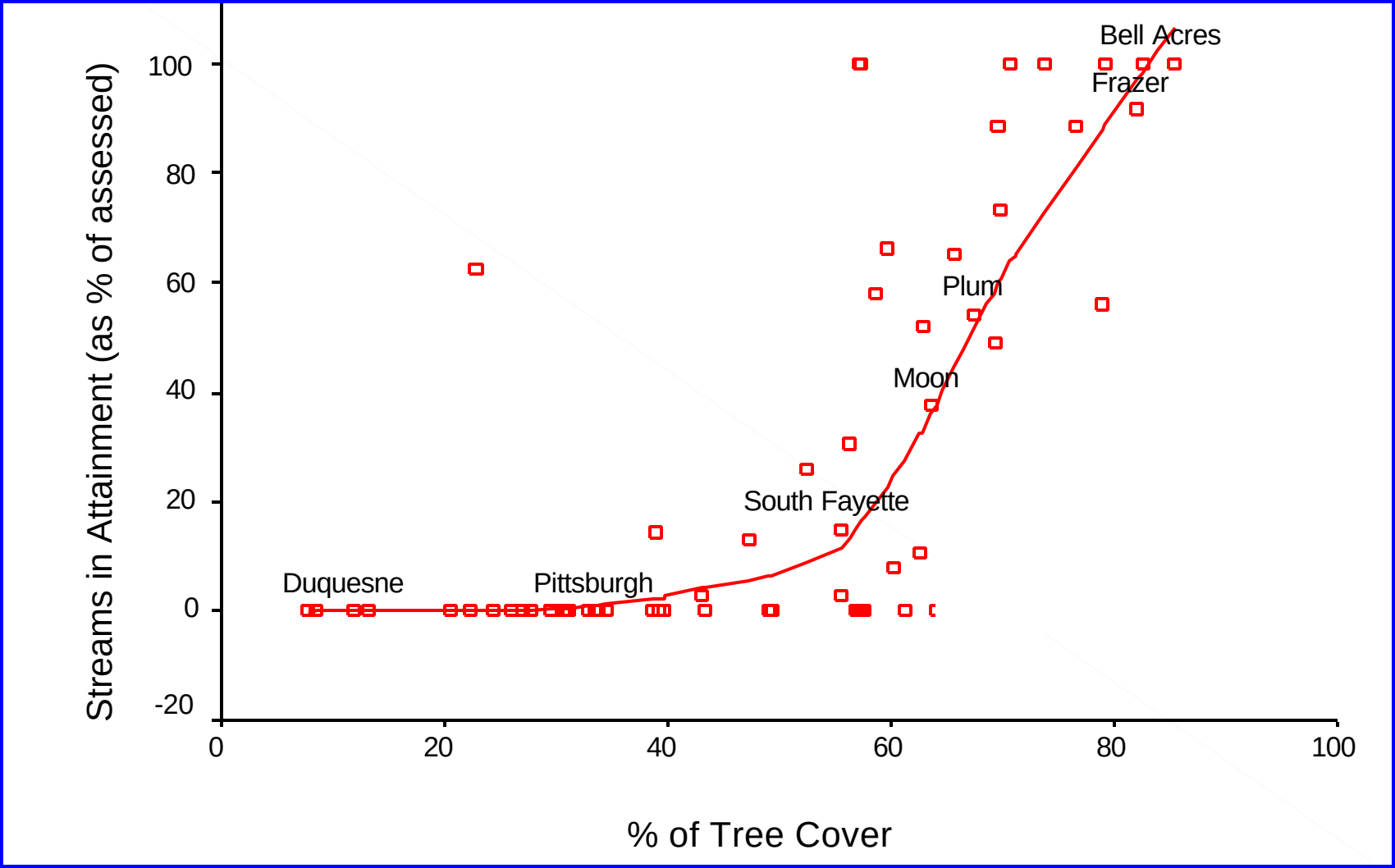


Figure 3

Tree Cover and Attainment of CWA, Allegheny County, PA (Argueta and Farber, 2001)



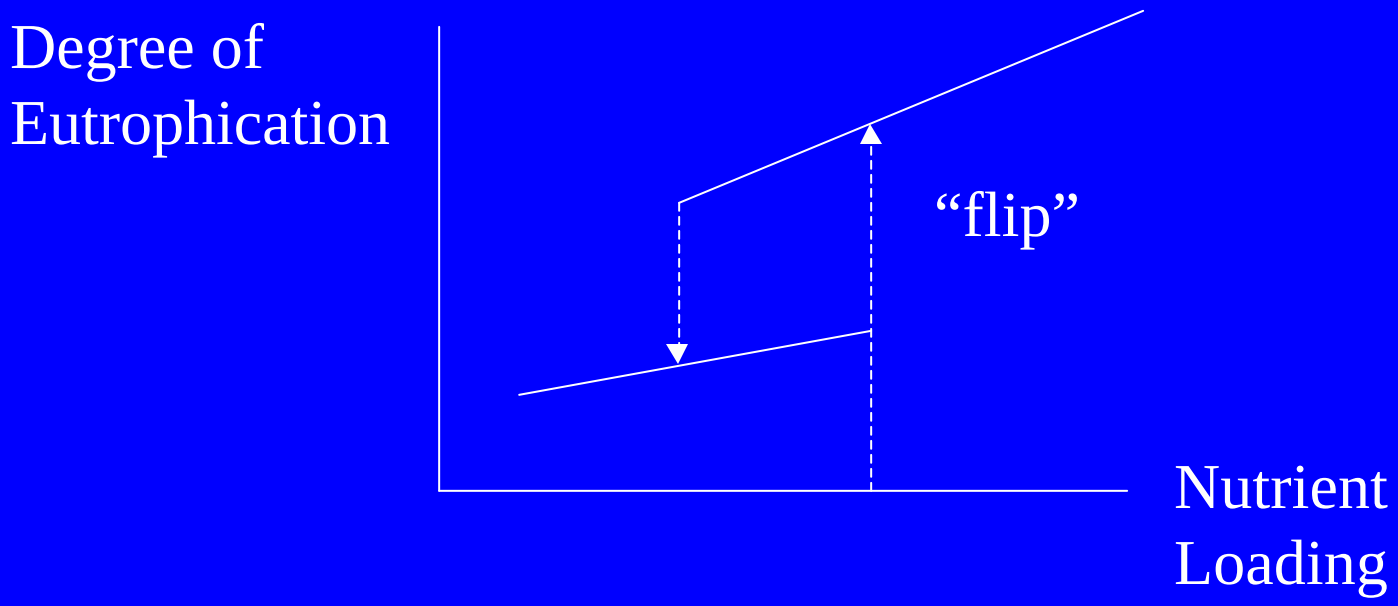
The valuation:

- Cumulative losses of forest cover from 80% cover to 60% cover may reduce stream attainment of water quality standards from nearly 100% to 20% in Allegheny County.
- Typical households in western Pennsylvania are willing to pay between $26 and $51 per household per year for five years to improve impaired streams from moderately to unpolluted conditions (Farber and Griner, 2000)

- Assuming roughly 4000 households per township, losses in water quality of this magnitude are worth between $104,000 and $204,000 per year for five years, or between $0.52 and $1.02 million for the impacted township
- Assuming water quality losses are proportional to loss of tree cover, each percent reduction in tree cover from a development activity in this example would be worth from $26,000 to $51,000
- Basis for a development fee!!

- Climate and atmospheric quality are related to the biodiversity of urban environments.
  - The study of urban heat islands shows a dramatic impact of urbanization and loss of vegetation on both temperature and hydrologic regimes (Filho, 2001).
  - Estimates that forests may sequester between 100 and 125 tons of carbon per hectare, combined with estimated global climate change costs, suggest keeping a forest standing is worth between $1300 and $1625 per hectare (Lampietti and Dixon, 1995).

Insurance Value-Nutrient Assimilation Capacity



Value = Cost avoided by not having to reverse loading

Source: Carpenter, et al., 2001

Isn’t Sprawl an Inexorable Result of Simple Market Forces?

- Market forces drive land to its most profitable use.
- Agricultural land is crowded out by higher valued urban uses.
- Forests are cut for more profitable housing developments.

Yet…

- Subsidies distort markets in determining land uses.
  - Construction of highways, not fully paid for by users.
  - Local taxation subsidies of residential housing.
    - A study of six Pennsylvania communities found that residential associated public service costs (schools, sewers, highways, etc.) ranged from 3% to 111% more than associated revenues to the taxing community (Kelsey, 1995).
- Socially valuable services of natural systems do not explicitly enter market processes, so their loss is not considered in market transactions.